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ANNEXES 1 to 4

ANNEXES

to the

COMMISSION REGULATION

**laying down ecodesign requirements for electric motors and variable speed drives
pursuant to Directive 2009/125/EC of the European Parliament and of the Council**

and repealing Commission Regulation (EC) No 640/2009

ECODESIGN REQUIREMENTS FOR MOTORS AND VARIABLE SPEED DRIVES**1. ENERGY EFFICIENCY REQUIREMENTS FOR MOTORS**

Energy efficiency requirements for motors shall apply according to the following timetable:

(a) from 15 January 2021:

the energy efficiency of three-phase motors with a rated output equal to or above 0,75 kW and equal to or below 1 000 kW, with 2, 4 or 6 poles, which are not brake motors, increased safety motors, or other explosion-protected motors, shall correspond to at least the IE3 efficiency level set out in Table 2 ;

(b) from 1 July 2022:

(i) the energy efficiency of three-phase motors with a rated output equal to or above 0,12 kW and below 0,75 kW, single-phase motors with a rated output equal to or above 0,12 kW and increased safety motors with a rated output equal to or above 0,12 kW and equal to or below 1 000 kW shall correspond to at least the IE2 efficiency level set out in Table 1;

(ii) the energy efficiency of three-phase motors with a rated output equal to or above 0,75 kW and equal to or below 1 000 kW with 2, 4, 6 or 8 poles, that are not increased safety motors, shall correspond to at least the IE3 efficiency level.

Energy efficiency for motors, expressed in International Energy efficiency classes (IE), is set out in Tables 1, 2 and 3, for different values of the motor rated output power P_N . IE classes are determined at rated output power (P_N), rated voltage (U_N), based on the 50 Hz operation and 25 °C ambient reference temperature.

Table 1: Minimum efficiencies η_n for IE2 efficiency level at 50 Hz (%)

Rated output power P_N [kW]	Number of poles			
	2	4	6	8
0,12	53,6	59,1	50,6	39,8
0,18	60,4	64,7	56,6	45,9
0,20	61,9	65,9	58,2	47,4
0,25	64,8	68,5	61,6	50,6
0,37	69,5	72,7	67,6	56,1
0,40	70,4	73,5	68,8	57,2
0,55	74,1	77,1	73,1	61,7
0,75	77,4	79,6	75,9	66,2
1,1	79,6	81,4	78,1	70,8
1,5	81,3	82,8	79,8	74,1
2,2	83,2	84,3	81,8	77,6
3	84,6	85,5	83,3	80,0
4	85,8	86,6	84,6	81,9
5,5	87,0	87,7	86,0	83,8
7,5	88,1	88,7	87,2	85,3
11	89,4	89,8	88,7	86,9

15	90,3	90,6	89,7	88,0
18,5	90,9	91,2	90,4	88,6
22	91,3	91,6	90,9	89,1
30	92,0	92,3	91,7	89,8
37	92,5	92,7	92,2	90,3
45	92,9	93,1	92,7	90,7
55	93,2	93,5	93,1	91,0
75	93,8	94,0	93,7	91,6
90	94,1	94,2	94,0	91,9
110	94,3	94,5	94,3	92,3
132	94,6	94,7	94,6	92,6
160	94,8	94,9	94,8	93,0
200 up to 1 000	95,0	95,1	95,0	93,5

Table 2: Minimum efficiencies η_n for IE3 efficiency level at 50 Hz (%)

Rated output power P_N [kW]	Number of poles			
	2	4	6	8
0,12	60,8	64,8	57,7	50,7
0,18	65,9	69,9	63,9	58,7
0,20	67,2	71,1	65,4	60,6
0,25	69,7	73,5	68,6	64,1
0,37	73,8	77,3	73,5	69,3
0,40	74,6	78,0	74,4	70,1
0,55	77,8	80,8	77,2	73,0
0,75	80,7	82,5	78,9	75,0
1,1	82,7	84,1	81,0	77,7
1,5	84,2	85,3	82,5	79,7
2,2	85,9	86,7	84,3	81,9
3	87,1	87,7	85,6	83,5
4	88,1	88,6	86,8	84,8
5,5	89,2	89,6	88,0	86,2
7,5	90,1	90,4	89,1	87,3
11	91,2	91,4	90,3	88,6
15	91,9	92,1	91,2	89,6
18,5	92,4	92,6	91,7	90,1
22	92,7	93,0	92,2	90,6
30	93,3	93,6	92,9	91,3
37	93,7	93,9	93,3	91,8
45	94,0	94,2	93,7	92,2
55	94,3	94,6	94,1	92,5
75	94,7	95,0	94,6	93,1
90	95,0	95,2	94,9	93,4
110	95,2	95,4	95,1	93,7
132	95,4	95,6	95,4	94,0

160	95,6	95,8	95,6	94,3
200 up to 1 000	95,8	96,0	95,8	94,6

Table 3: Minimum efficiencies η_n for IE4 efficiency level 50 Hz (%)

Rated output power P_N [kW]	Number of poles			
	2	4	6	8
0,12	66,5	69,8	64,9	62,3
0,18	70,8	74,7	70,1	67,2
0,20	71,9	75,8	71,4	68,4
0,25	74,3	77,9	74,1	70,8
0,37	78,1	81,1	78,0	74,3
0,40	78,9	81,7	78,7	74,9
0,55	81,5	83,9	80,9	77,0
0,75	83,5	85,7	82,7	78,4
1,1	85,2	87,2	84,5	80,8
1,5	86,5	88,2	85,9	82,6
2,2	88,0	89,5	87,4	84,5
3	89,1	90,4	88,6	85,9
4	90,0	91,1	89,5	87,1
5,5	90,9	91,9	90,5	88,3
7,5	91,7	92,6	91,3	89,3
11	92,6	93,3	92,3	90,4
15	93,3	93,9	92,9	91,2
18,5	93,7	94,2	93,4	91,7
22	94,0	94,5	93,7	92,1
30	94,5	94,9	94,2	92,7
37	94,8	95,2	94,5	93,1
45	95,0	95,4	94,8	93,4
55	95,3	95,7	95,1	93,7
75	95,6	96,0	95,4	94,2
90	95,8	96,1	95,6	94,4
110	96,0	96,3	95,8	94,7
132	96,2	96,4	96,0	94,9
160	96,3	96,6	96,2	95,1
200 up to 249	96,5	96,7	96,3	95,4
250 up to 314	96,5	96,7	96,5	95,4
315 up to 1 000	96,5	96,7	96,6	95,4

The losses corresponding to minimum efficiencies for the IE5 level are 20 % lower than the losses corresponding to the minimum efficiencies for IE4 presented in Table 3.

To determine the minimum efficiency of 50 Hz motors with rated power outputs P_N of between 0,12 and 200 kW not provided in Tables 1, 2 and 3, the following formula shall be used:

$$\eta_n = A \cdot [\log_{10}(P_N/1kW)]^3 + B \cdot [\log_{10}(P_N/1kW)]^2 + C \cdot \log_{10}(P_N/1kW) + D$$

A, B, C and D are interpolation coefficients to be determined according to Tables 4 and 5.

Table 4: Interpolation coefficients for motors with rated power output P from 0,12 kW up to 0,55 kW

IE code	Coefficients	2 poles	4 poles	6 poles	8 poles
IE2	A	22,4864	17,2751	-15,9218	6,4855
	B	27,7603	23,978	-30,258	9,4748
	C	37,8091	35,5822	16,6861	36,852
	D	82,458	84,9935	79,1838	70,762
IE3	A	6,8532	7,6356	-17,361	-0,5896
	B	6,2006	4,8236	-44,538	-25,526
	C	25,1317	21,0903	-3,0554	4,2884
	D	84,0392	86,0998	79,1318	75,831
IE4	A	-8,8538	8,432	-13,0355	-4,9735
	B	-20,3352	2,6888	-36,9497	-21,453
	C	8,9002	14,6236	-4,3621	2,6653
	D	85,0641	87,6153	82,0009	79,055

Between 0,55kW and 0,75 kW, a linear interpolation shall be performed.

Table 5: Interpolation coefficients for motors with rated power output P from 0,75 kW up to 200 kW

IE code	Coefficients	2 poles	4 poles	6 poles	8 poles
IE2	A	0,2972	0,0278	0,0148	2,1311
	B	-3,3454	-1,9247	-2,4978	-12,029
	C	13,0651	10,4395	13,247	26,719
	D	79,077	80,9761	77,5603	69,735
IE3	A	0,3569	0,0773	0,1252	0,7189
	B	-3,3076	-1,8951	-2,613	-5,1678
	C	11,6108	9,2984	11,9963	15,705
	D	82,2503	83,7025	80,4769	77,074
IE4	A	0,34	0,2412	0,3598	0,6556
	B	-3,0479	-2,3608	-3,2107	-4,7229
	C	10,293	8,446	10,7933	13,977
	D	84,8208	86,8321	84,107	80,247

2. PRODUCT INFORMATION REQUIREMENTS FOR MOTORS

The product information requirements set out in points (1) to (13) below shall be visibly displayed on:

- (a) the technical data sheet or user manual supplied with the motor;
- (b) the technical documentation for the purposes of conformity assessment pursuant to Article 5;
- (c) free access websites of the manufacturer of the motor its authorised representative or the importer, and;
- (d) the technical data sheet or user manual supplied with products in which the motor is incorporated.

As regards to the technical documentation, the information shall be provided in the order as set out in points (1) to (13). The exact wording used in the list does not need to be repeated. The information may be displayed using clearly understandable graphs figures or symbols rather than text:

- (1) rated efficiency (η_N) at the full, 75 % and 50 % rated load and voltage (U_N), determined based on the 50 Hz operation and 25 °C ambient reference temperature;
- (1) efficiency level: ‘IE2’ ‘IE3’ ‘IE4’ or ‘IE5’, as determined as specified in the first section of this annex, followed by the term “-motor”
- (2) manufacturer’s name or trade mark, commercial registration number and address;
- (3) product’s model identifier;
- (4) number of poles of the motor;
- (5) the rated power output(s) P_N or range of rated power output (kW);
- (6) the rated input frequency(s) of the motor (Hz);
- (7) the rated voltage(s) or range of rated voltage (V);
- (8) the rated speed(s) or range of rated speed (rpm);
- (9) whether single-phase or three-phase;
- (10) information on the range of operating conditions for which the motor is designed:
 - (a) altitudes above sea-level;
 - (b) minimum and maximum ambient air temperatures including for motors with air cooling;
 - (c) water coolant temperature at the inlet to the product, where applicable;
 - (d) maximum operating temperature;
 - (e) potentially explosive atmospheres;
- (11) information relevant for disassembly recycling or disposal at end-of-life;
- (12) if the motor is considered exempt from efficiency requirement in accordance with Article 4(2) of this Regulation: the specific reason why it is considered exempt.

The information referred to in points (1) and (2) as well as the year of manufacture shall be durably marked on or near the rating plate of the motor. Where the size of the rating plate makes it impossible to mark all the information referred to in point (1) only the rated efficiency at full rated load and voltage shall be marked.

The information listed in points (1) to (13) does not need to be published on free access websites for tailor-made motors with a special mechanical and electrical design manufactured on the basis of a specific client request if this information is included in the commercial offers provided to the clients.

Manufacturers shall provide information in the technical data sheet or user manual supplied with the motor on any specific precautions that must be taken when motors are assembled installed maintained or used with variable speed drives.

For motors exempt from the efficiency requirements in accordance with Article 4(2)(m) of this Regulation, the motor or its packaging and the documentation must clearly indicate ‘Motor to be used exclusively as spare part for’ and the product(s) for which it is intended.

For 50/60 Hz and 60 Hz motors, the information set out in points (1) and (2) above may be provided for the 60 Hz operation in addition to the values at 50 Hz, with clear indication of the applicable frequencies.

3. EFFICIENCY REQUIREMENTS FOR VARIABLE SPEED DRIVES

Efficiency requirements for variable speed drives shall apply as follows:

from 15 January 2021, the power losses of variable speed drives rated for operating with motors with a rated output equal to or above 0,75 kW and equal to or below 1 000 kW shall not exceed the maximum power losses corresponding to the IE2 efficiency level.

Energy efficiency for VSDs, expressed in International Energy efficiency classes (IE), is determined based on the power losses as follows:

The maximum power losses of the IE2 class are 25 % lower than the reference value referred to in table 6.

The maximum power losses of the IE3 class are 43,75 % lower than the reference value.

The maximum power losses of the IE4 class are 57,81 % lower than the reference value.

Table 6 – Reference VSD losses and test load displacement factor for the IE class determination of VSDs

Apparent output power of VSD (kVA)	Rated power of Motor (kW)	Reference power losses (kW) at 90% speed and 100% torque	Test load displacement factor cos phi
1,29	0,75	0,142	0,79
1,71	1,1	0,163	0,79
2,29	1,5	0,188	0,79
3,3	2,2	0,237	0,79
4,44	3	0,299	0,79
5,85	4	0,374	0,79
7,94	5,5	0,477	0,85
9,95	7,5	0,581	0,85
14,4	11	0,781	0,85
19,5	15	1,01	0,85
23,9	18,5	1,21	0,85
28,3	22	1,41	0,85
38,2	30	1,86	0,85
47	37	2,25	0,85
56,9	45	2,70	0,86
68,4	55	3,24	0,86
92,8	75	4,35	0,86
111	90	5,17	0,86
135	110	5,55	0,86
162	132	6,65	0,86
196	160	8,02	0,86
245	200	10,0	0,87
302	250	12,4	0,87

381	315	15,6	0,87
429	355	17,5	0,87
483	400	19,8	0,87
604	500	24,7	0,87
677	560	27,6	0,87
761	630	31,1	0,87
858	710	35,0	0,87
967	800	39,4	0,87
1 088	900	44,3	0,87
1 209	1 000	49,3	0,87

If the power output of a VSD is between two values in Table 6, the higher power loss value and the lower value of the test load displacement factor shall be used for the IE class determination.

For testing, a tolerance of +/- 0,08 of the test load displacement factor $\cos \phi$ in table 6 is allowed.

4. PRODUCT INFORMATION REQUIREMENTS FOR VSIDS

The product information on variable speed drives set out in points (1) to (9) shall be visibly displayed on:

- (a) the technical data sheet or user manual supplied with the VSD;
- (b) the technical documentation for the purposes of conformity assessment pursuant to Article 5;
- (c) free access websites of the manufacturer its authorised representative or the importer and;
- (d) the technical data sheet or user manual supplied with products in which the VSD is incorporated.

As regards to the technical documentation, the information shall be provided in the order as listed in points (1) to (9). The exact wording used in the list does not need to be repeated. It may be displayed using clearly understandable graphs figures or symbols rather than text:

- (1) power losses (W) at the following different operating points for speed versus torque (25;25) (25;100) (50;25) (50;50) (50;100) (90;50) (90;100);
- (2) efficiency level: 'IE1' 'IE2' 'IE3' or 'IE4', followed by the tem "-VSD";
- (3) manufacturer's name or trade mark commercial registration number and place of manufacture;
- (4) product's model identifier;
- (5) the motor rated power output(s) P_N or range of rated power output (kW);
- (6) the rated supply frequency(s) (Hz);
- (7) the rated supply voltage(s) or range of rated supply voltage (V);
- (8) information relevant for disassembly recycling or disposal at end-of-life;
- (9) if the VSD is considered exempt from the efficiency requirements in accordance with Article 4(3) of this Regulation the specific reason why it is considered exempt.

The information listed above in points (1) to (9) does not need to be published on free access websites for tailor-made VSDs with special electrical design manufactured on the basis of a specific client request if this information is included in the commercial offers provided to the clients.

For VSDs exempt from the efficiency requirements in accordance with Article 4(3)(c) of this Regulation the VSD or its packaging and the documentation must clearly indicate ‘Variable Speed Drive to be used exclusively as spare part for’ and the product(s) for which it is intended.

ANNEX II
MEASUREMENT METHODS

For the purposes of compliance and verification of compliance with the requirements of this Regulation, measurements and calculations shall be made using harmonised standards the reference numbers of which have been published for this purpose in the *Official Journal of the European Union* or other reliable accurate and reproducible methods which take into account the generally recognised state-of-the-art and in line with the following provisions:

1. FOR MOTORS

For the purpose of the requirements set in annex I (1) and (2) for 60 Hz motors, equivalent values of the rated output power (P_N) and rated voltage (U_N) for the 50 Hz operation shall be calculated based on the values applicable at 60 Hz.

The difference between the output mechanical power and the input electrical power is due to losses occurring in the motor. Total losses shall be determined using the following methods:

- Single phase motors: Direct measurement: Input-Output;
- Three-phase motors: Summation of losses: Residual losses.

2. FOR VARIABLE SPEED DRIVES

For the determination of the IE class, the power losses of VSDs shall be determined at 100 % rated torque producing current and 90 % rated motor stator frequency according to one of the following methods:

- the input-output method; or
- the calorimetric method.

The test switching frequency shall be 4 kHz until 90 kW (111 kVA) and 2 kHz above.

ANNEX III

VERIFICATION PROCEDURE FOR MARKET SURVEILLANCE PURPOSES

The verification tolerances defined in this Annex relate only to the verification of the measured parameters by Member State authorities and shall not be used by the manufacturer or importer as an allowed tolerance to establish the values in the technical documentation or in interpreting these values with a view to achieving compliance or to communicate better performance by any means.

When verifying that a product model complies with the requirements laid down in this Regulation pursuant to Article 3(2) of Directive 2009/125/EC for the requirements referred to in this Annex the authorities of the Member States shall apply the following procedure.

- (1) The Member State authorities shall verify one single unit of the model.
- (2) The model shall be considered to comply with the applicable requirements if:
 - (a) the values given in the technical documentation pursuant to point 2 of Annex IV to Directive 2009/125/EC (declared values) and where applicable the values used to calculate these values are not more favourable for the manufacturer or importer than the results of the corresponding measurements carried out pursuant to point (g) thereof; and
 - (b) the declared values meet any requirements laid down in this Regulation and any required product information published by the manufacturer or importer does not contain values that are more favourable for the manufacturer or importer than the declared values; and
 - (c) when the Member State authorities test the unit of the model the determined values (the values of the relevant parameters as measured in testing and the values calculated from these measurements) including the total losses (1- η) as the decisive criterion for the efficiency comply with the respective verification tolerances as set out in Table 7.
- (3) If the results referred to in points (2)(a) or (2)(b) are not achieved the model and all equivalent models shall be considered not to comply with this Regulation.
- (4) If the result referred to in point (2)(c) is not achieved;
 - (a) for models that are produced in quantities of less than five per year the model shall be considered not to comply with this Regulation;
 - (b) for models that are produced in quantities of five or more per year the Member State authorities shall select three additional units of the same model for testing. As an alternative one or more of the three additional units selected may be of an equivalent model. The model shall be considered to comply with the applicable requirements if for these three units the arithmetical mean of the determined values including the total losses (1- η) as decisive criterion for the efficiency complies with the respective verification tolerances given in Table 7.
- (5) If the result referred to in point (4)(b) is not achieved the model and all equivalent models shall be considered not to comply with this Regulation.
- (6) The Member State authorities shall provide all relevant information to the authorities of the other Member States and to the Commission without delay after a decision is taken on the non-compliance of the model according to points (3) (4)(a) and (5).

The Member State authorities shall use the measurement and calculation methods set out in Annex II.

Given the weight and size limitations for the transportation of motors and variable speed drives with a rated power output of 375 to 1 000 kW Member States authorities may decide to undertake the verification procedure at the premises of manufacturers or importers before the products are put into service.

The Member State authorities shall only apply the tolerances set out in Table 7 and shall only use the procedure described in points (1) to (6) for the requirements referred to in this Annex. No other tolerances such as those set out in harmonised standards or in any other measurement method shall be applied.

Table 7 — Verification tolerances	
<i>Parameters</i>	<i>Verification tolerances</i>
Total losses (1- η) for motors with a rated output equal to or above 0.12 kW and equal to or below 150 kW.	The determined value shall not exceed the value (1- η) calculated based on the declared η by more than 15 %.
Total losses (1- η) for motors with a rated output of above 150 kW and equal to or below 1 000 kW.	The determined value shall not exceed the value (1- η) calculated based on the declared η by more than 10 %.
Total losses for variable speed drives.	The determined value shall not exceed the declared value by more than 5 %.

ANNEX IV
INDICATIVE BENCHMARKS

At the time of adoption of this Regulation the best available technology on the market for the environmental aspects that were considered significant and are quantifiable is indicated below.

For motors the IE4 level was identified as the best available technology. IE5 motors exist but within limited availability and not in all power ranges covered by this Regulation and not in the form of induction motors.

For variable speed drives the IE4 level was identified as the best available technology assumed to correspond to power losses equal to or lower than 56,3 % of the IE2 maximum power losses although there is not yet an internationally agreed standard that defines the IE4 level.